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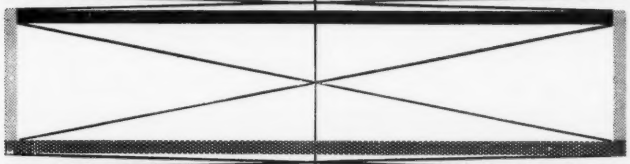

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ANNALS OF PHYSICAL MEDICINE

The Official Organ of the
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Vol. V May 1959 No. 2

ORIGINAL PAPER

CERVICAL SPONDYLOSIS: PILOT THERAPEUTIC TRIAL

By V. L. STEINBERG and R. M. MASON

From the Department of Physical Medicine and Regional Rheumatism Centre of the London Hospital

DESPITE the pleas of Boyle, Richardson, and Doll (1954) there subsequently have been few published reports of controlled trials into the efficacy or otherwise of physiotherapeutic methods in the treatment of cervical spondylosis. A review of these *Annals* during the past three years, indeed, reveals but one—that of Lawrence and Sladden (1955).

The present communication reports a pilot study of three commonly used forms of physical treatment for cervical spondylosis. This condition was selected because, as previously reported (Mason, 1956), almost one-third of all new patients referred to the Department of Physical Medicine and Regional Rheumatism Centre of the London Hospital do so with symptoms of osteoarthritis, the cervical spine being the most common presenting region. Moreover, patients with osteoarthritis occupy 28% of the total physiotherapy time available in the department.

Selection for the trial was based on a complaint of either neck and shoulder-girdle pain or peripheral paraesthesiae, or a combination of both, attributable to degenerative joint disease of the cervical spine, including changes due to disk degeneration—cervical spondylosis. Patients with long-tract symptoms or signs were excluded, and neurological signs in the upper limbs were not obligatory, and were in fact uncommon. Routine radiography was carried out to exclude other causes of pain, and an analysis of the X-ray findings is included. No limitations as to age, sex, or duration of symptoms were imposed, except

that initially, for administrative reasons, only females were included. This partly accounts for the numerical predominance of females over males in the series. The patients were seen and assessed during routine clinics, and all the members of the medical staff working in the department took part in the trial. Both sexes have been analysed separately, and such differences as appear are reported.

THERAPEUTIC REGIMENS

The following treatment groups were compared at the end of one month:

Group I. Heat, Massage, and Longitudinal Neck Traction

Heat was administered by a 1,000-watt luminous-heat lamp at a distance of 36 inches for 20 minutes. Subsequently manual massage in the form of effleurage and kneading was applied to the neck, shoulder girdle, and upper dorsal region. Traction was either manual or mechanical by means of a Sayers sling or by the Kuhlman apparatus with a 15-lb. pull for 15 minutes. Each treatment period lasted one hour and was applied individually three times a week for a month.

Group II. Felt Collar

These patients were fitted with a felt collar reinforced with strips of plastic and were instructed to wear this for as much of the 24 hours as was tolerable. The importance of wearing the collar during sleep was stressed.

Group III. Neck and Shoulder Girdle Exercises

These consisted of routine neck and shoulder girdle exercises as follows:

(i) *Crook Lying.*—Head movements—rotation and lateral flexion. Shoulder-shrugging movements. Arms stretching above head and down to sides.

(ii) *Prone Lying.*—Head and shoulder lifting and lowering.

(iii) *Prone Kneeling.*—Teach correct head position. Head movements —extension, rotation, and lateral flexion.

(iv) *Sitting.*—Shoulder shrugging with lateral flexion of head. Head rotation and extension with arm movements.

(v) *Standing.*—Arm exercises involving elevation (head following arm movements).

These were carried out on a class of six patients for half an hour three times a week for a month.

Group O. Physician's Free Choice

A further group was also included in which the physician had free choice of treatment to see whether he could "beat the book" by the exercise of his skill and experience, and to determine whether a random allocation of therapy was a fair, or even ethical, procedure.

Table I compares the time occupied by both patient and physiotherapist in carrying out the treatment during the one-month period of the trial, a relevant factor in assessing the relative value of any form of treatment. It is clear that large differences do exist in this respect, Group I being the most time-consuming and Group II more economical, the former occupying 24 times the length of time of the latter. Group III is reasonably economical of physiotherapist time because of the class methods used, though not, of course, so economical of the patient's time.

TABLE I

TREATMENT PROGRAMMES

Group	Treatment	Time Spent in Treatment during the One-month Period	
		Physiotherapist	Patient
O	Physician's free choice	Various	Various
I	Heat, massage, neck traction	12 hours	12 hours
II	Felt collar	30 minutes	30 minutes
III	Neck and shoulder girdle exercises	1 hour	6 hours

ALLOCATION TO TREATMENT GROUPS

Allocation to treatment group was made after selection for the trial, and depended upon the last figure of the patient's hospital registration number. To Group I were allocated patients whose numbers ended in 1, 2, or 3; to Group II, in 4, 5, and 6; and to Group III, in 7, 8, and 9. The patients whose last number was 0 were allocated to Group O. This method is open to the criticism that in fact the patient's number is known before selection, but in practice the registration number is not prominent and no difficulty was encountered on this score. A more serious fault lay in the bad distribution into groups that resulted by chance. Theoretically 30% should have fallen into each of the Groups I, II, and III, and 10% into Group O. In the event the percentage distribution was as shown in Table II. Clearly a centralized and randomized allocation to treatment groups is necessary.

TABLE II

PERCENTAGE DISTRIBUTION OF CASES IN TREATMENT GROUPS

Group	%
O	7
I	42
II	22
III	29

CLINICAL MATERIAL

By the time of analysis 116 females and 47 males, a total of 163 patients, had entered the trial. The mean age for the whole group was 50·9 years. The samples in the four treatment groups were reasonably homogeneous for age (Table III). Diagram 1 shows the age distribution by decades in the various

TABLE III

CLINICAL MATERIAL

Group	No.	Mean Age (years)	Range (years)
O	15	47·7	32–68
I	67	50·3	28–86
II	36	54·4	31–80
III	45	51·3	37–78
Total	163	50·9	28–86

treatment groups. It is of interest to compare the age of presentation of this material with that of the whole field of osteoarthritis (Diagram 2). It will be seen that the maximum incidence of this group is in the 40–49 decade, whilst osteoarthritis as a whole has a maximum incidence in the 50–59 decade. This is consistent with our suggestion that the cervical spine is the commonest presenting region of osteoarthritis.

RADIOGRAPHIC STUDIES

Despite the generally accepted view that radiological changes do not correlate with symptoms in degenerative joint disease (Kellgren and Lawrence, 1952; Lawrence, 1955), it was considered desirable to see whether the different

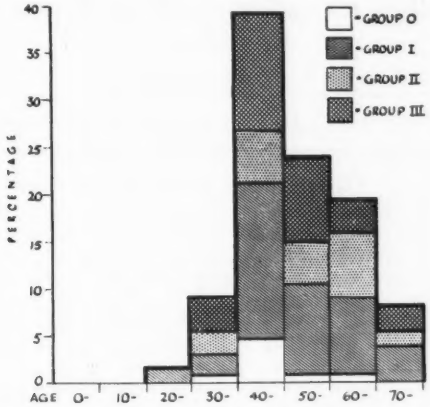

DIAGRAM 1.—Age distribution of treatment groups.

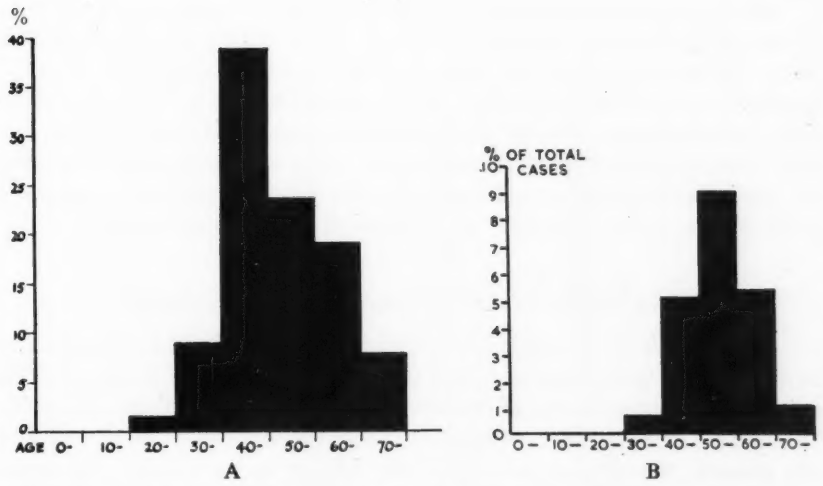

DIAGRAM 2.—(A) Age distribution of cases of cervical spondylosis compared with (B) age distribution of patients presenting with osteoarthritis as given by Mason (1956).

groups consisted of homogeneous samples so far as X-ray changes were concerned. All the films were read by one of us (V.L.S.) in consultation with other members of the department, and graded according to Kellgren and Lawrence (1957), except that the doubtful cases were recorded as "no change". Altogether

146 films were available for reading, and the distribution of these is given in Table IV.

TABLE IV

ANALYSIS OF SAMPLE OF 146 RADIOGRAPHS

X-ray Changes	Group I		Group II		Group III		Group O	
	No.	%	No.	%	No.	%	No.	%
None	9	14·7	5	15·2	5	12·8	0	0
Slight	25	41·0	14	42·4	14	35·9	4	30·8
Moderate	21	34·7	10	30·3	15	38·5	8	61·6
Severe	6	9·8	4	12·1	5	12·8	1	7·7

RADIOLOGICAL ANALYSIS

Radiographs were available on 91% of patients in Group I, 92% in Group II, and 87% in each of Groups III and O. These show a fair distribution of X-ray changes throughout the four treatment groups, except that Group O contained a rather high proportion with moderate changes and a lower proportion of severe changes than the other treatment groups. It is clear, however, that there was no undue preponderance such as might have influenced the results. No particular treatment group was likely to have an advantage, or to be at a disadvantage, so far as severity of radiological change is concerned.

ASSESSMENT OF THERAPEUTIC RESPONSE

Since pain is the presenting feature rather than functional impairment due to limitation of joint range, and since the primary objective of treatment is the relief of pain, assessment of therapeutic response was entirely subjective. "Blindfold" methods were not used, and observer bias cannot be excluded by this method. Nevertheless this was a pilot inquiry to see whether any trends could be observed. No preconceived views were held by the observers, who were, as we have pointed out, all the medical staff acting simply in the course of routine out-patient clinics. There was no particular reason why any one treatment should benefit by any special bias. It may be that it would be possible to devise a method whereby the assessments could be carried out by an observer to whom the type of treatment given is unknown. All patients were reviewed at two and four weeks after entering the trial, and assessed as cured, improved, unchanged, or worse. The results at four weeks are reported here.

RESULTS

TABLE V

RESULTS OVER-ALL AND ACCORDING TO SEX

	Over-all		Males		Females	
	No.	%	No.	%	No.	%
Entered	163	100	47	100	116	100
Defaulted	17	10·4	5	10·6	12	10·3
Studied	146	100	42	100	104	100
"Cured"	17	11·6	4	9·5	13	12·5
Improved	90	61·6	25	59·5	65	62·5
Over-all improvement ..	107	73·2	29	69·0	78	75·0
Unchanged	29	19·9	9	21·4	20	19·2
Worse	10	6·9	4	9·6	6	5·8

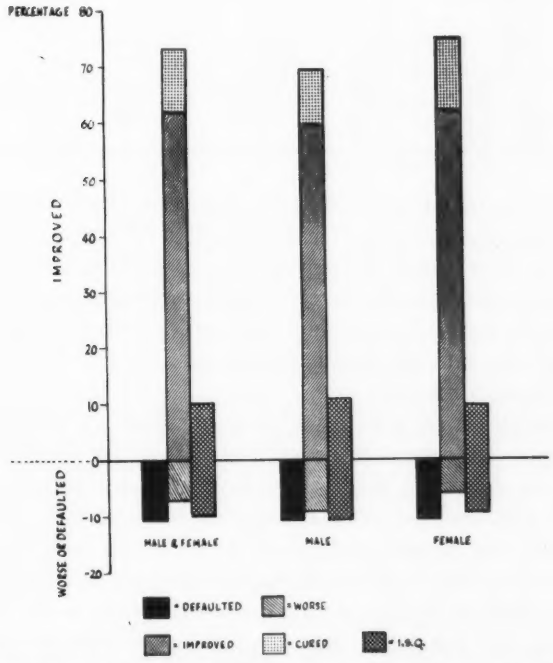

DIAGRAM 3.—Status following treatment—over-all and by sex.

Table V shows the results over-all and according to sex, independent of treatment group. In Diagram 3 the results are given as percentages of the numbers studied for comparison.

The defaulter rate of 10% is the same for both sexes. Of the patients studied at one month, 73·2% were improved or cured; 11·6% expressed themselves as cured; 6·9% were worse. Comparison of the sexes shows no significant difference, 75% of the females and 69% of the males being improved or cured.

TABLE VI

COMPARISON OF TREATMENT GROUPS

	Group O		Group I		Group II		Group III	
	No.	%	No.	%	No.	%	No.	%
Entered	15	100	67	100	36	100	45	100
Defaulted	2	13·3	6	9·0	3	8·3	6	13·3
Studied	13	100	61	100	33	100	39	100
Cured	1	7·7	7	11·5	3	9·1	6	15·4
Improved	8	61·5	36	59·0	24	72·7	22	56·4
Over-all improved ..	9	69·2	43	70·5	27	81·8	28	71·8
Unchanged	4	30·8	15	24·6	4	12·1	6	15·4
Worse	0	0	3	4·9	2	6·1	5	12·8

Table VI (Diagram 4) shows the comparative results in the different treatment groups independent of sex. Treatment with a felt collar (Group II) comes out best with an 81·8% improvement rate, whilst the other groups are all some 10% lower. Groups O and III have the highest defaulter rate of 13·3%, and Group III, whilst showing the highest aggravation rate (12·8%) and sharing the highest defaulter rate, also has the highest cure rate (15·4%). It may be that it is a "kill or cure" form of therapy.

If we separate males and females and compare the different treatment groups, Group II still comes out best (Table VII). There was an 86% over-all improvement for males and 80·7% for females in this group, but there was a 22% defaulter rate amongst males ordered collars compared with only 3·7% amongst females. We suggest that it is more difficult for men, who have to go to work, to wear a collar than for the housewife in her own home, or perhaps men are less willing to disguise the appliance by wearing a silk scarf than are women. Males also did better than females in the exercise therapy group (Group III), having an 83·6% over-all improvement rate as compared with

66·6% for the females. On the other hand, females did better than males in Group I, a 77·2% over-all improvement being recorded as compared with 53% for males. None of the females in Group I was made worse, compared with 18% of the males, whilst 18·5% of the females in Group III were worse and none of the males.

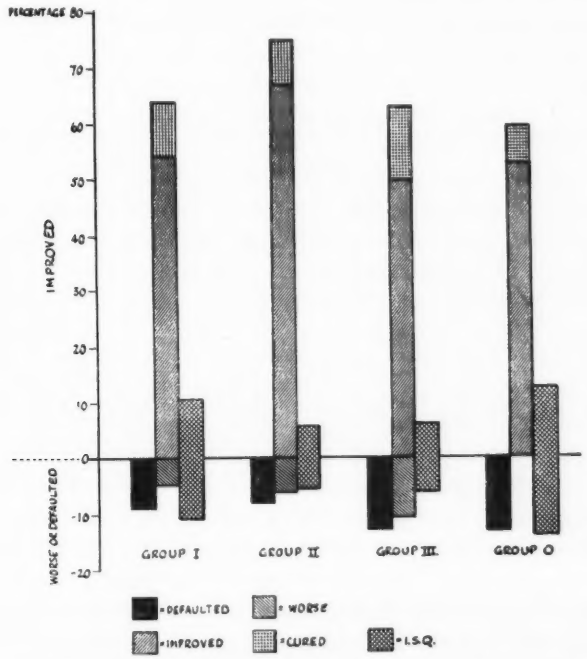

DIAGRAM 4.—Comparison of treatment groups at one month.

DISCUSSION

Although we realize that the numbers studied are small and the treatment groups unequal in size, it must be pointed out that this is no more than an exploratory or pilot trial to gain experience and bring to light unforeseen difficulties and to observe possible trends to help in designing a full-scale trial. We feel justified in presenting these results, as they show the difficulties encountered in performing such an investigation, and from this we think we have learnt how to avoid many of the pitfalls in the future. We hope that this account will be of help to others who are planning to undertake similar investigations.

It will be seen that Group II gave the best results irrespective of whether

the sexes were separated or not. As shown by the higher defaulter rate, it does appear that males dislike the idea of wearing a collar. Males and females do equally well in a collar, but this is not the case for the other treatment regimens. Thus women do better with heat, massage, and traction than with exercises, whereas the men do better with exercises. The defaulter rate was, however, higher with men in the exercise group than in the traction group. If these defaulters had attended for treatment and assessment the results might have

TABLE VII

COMPARISON OF TREATMENT GROUPS BY SEX

	Group O				Group I				Group II				Group III			
	Males		Females		Males		Females		Males		Females		Males		Females	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Entered	6	100	9	100	18	100	49	100	9	100	27	100	14	100	31	100
Defaulted ..	0	0	2	22	1	5·5	5	10	2	22	1	3·7	2	14·3	4	10·1
Studied ..	6	100	7	100	17	100	44	100	7	100	26	100	12	100	27	100
Cured	1	17	0	0	1	6	6	13·6	0	0	3	11·5	2	16·6	4	14·8
Improved ..	3	50	5	71·4	8	47	28	63·6	6	86	18	69·2	8	67	14	51·8
Over-all improved ..	4	67	5	71·4	9	53	34	77·2	6	86	21	80·7	10	83·6	18	66·6
Unchanged ..	2	33	2	28·6	5	29	10	23	0	0	4	15·4	2	16·6	4	14·8
Worse	0	0	0	0	3	18	0	0	1	14	1	3·9	0	0	5	18·5

been different. Group II treatment occupies by far the least time for both physiotherapist and patient. This is of great economic importance, if our figures showing that this regimen gives the best results are correct and can be confirmed. If a collar does in fact give the best results and this method of treatment was more widely adopted there would result a great saving in time expended by physiotherapists, who would then be available to treat other, perhaps more important, conditions. Time and expense would also be saved to the patients, since they can perform their routine work wearing a collar. Taking the patients as a whole there was an over-all improvement of 73·2%. In analysing the groups and further separating the sexes the over-all improvement always exceeded 50%, males in Group I showing the lowest over-all improvement of only 53%.

It appears that, whatever the treatment, the majority of patients with symptoms due to cervical spondylosis will be improved when reviewed at the end of one month, and it is also clear that the arbitrary selection of treatment

by the method described is a perfectly ethical procedure. Whether this rate of improvement is a result of treatment or reflects the natural history of the condition is a question which requires study. It may be that different treatments are effective for different types of patient. If the physician could allocate the individual patient to the proper treatment group a higher rate of improvement might be obtained, although it must be admitted that our figures lend no support to such a complacent hypothesis. In any further trial a much higher degree of stratification of the various features would be required. Table VII shows how small the numbers in each section become if material is broken down into groups according to sex, treatment, and response. In a full-scale trial not less than ten times the number of patients would be desirable—perhaps 2,000 cases in all. We estimate that this would require ten centres carrying out a co-operative trial over a period of approximately 18 months. For future trials a placebo treatment group would be essential. It seems clear that nothing less than a multicentre and centrally controlled therapeutic trial would produce sufficient clinical material for adequate answers to the many questions posed.

SUMMARY AND CONCLUSIONS

A description is given of a pilot trial to evaluate three different therapeutic regimens commonly used in the treatment of cervical spondylosis.

It seems probable that the application of a supporting collar produces the highest improvement rate. This method is the most economical in time to both patient and physiotherapist.

Suggestions are made for the design of a centrally controlled multicentre therapeutic trial.

ACKNOWLEDGMENTS

We would like to express our thanks to Dr. W. S. Tegner, under whose care most of the patients were, and to Miss Orme, Principal of the London Hospital School of Physiotherapy, and her staff for their interest and willing co-operation.

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ORIGINAL PAPER

ABBREVIATED ELECTRODIAGNOSTIC TESTS OF DENERVATION*

A COMPARATIVE STUDY

By L. D. AMICK† and R. P. HICKEY

From the Department of Physical Medicine and Rheumatology, Royal Free Hospital, London, and the Royal Air Force Medical Rehabilitation Unit, Chessington

STUDY of the different electrical responses of normal and pathological voluntary muscle has allowed the designing of a remarkable variety of electrodiagnostic techniques. In modern clinical practice, however, it is the measurement of neuromuscular excitability as expressed clinically by an intensity–duration (I/T) curve that has become the most widely used. Indeed, for accuracy and convenience in the detection of denervation this method is unrivalled, and combined with electromyography it forms the basis of the most generally used routine technique (Richardson and Wynn Parry, 1957). When used in combination with electromyography, I/T curves may be abbreviated by limiting the intensity measurements to two stimulus durations only and determining the ratio between them. In this way reliance is placed on electromyography for the detection of minimal denervation, the differentiation of severe partial and complete denervation, and the detection of early recovery. This abbreviated technique is rapidly and easily carried out, particularly with an electronic square pulse stimulator incorporating a variable shunt across the intensity meter (Bauwens and Richardson, 1950), and it is for this reason that it is being increasingly used alone for the detection of denervation, even though the error inherent in such a technique is unknown.

The well-known change in muscle-fibre accommodation that follows denervation also allows a rapid test for the detection of denervation, in this instance based on determination of the progressive current ratio. This method, although shown by Pollock *et al.* (1945) to be of diagnostic value in 52 patients with peripheral nerve lesions, has not yet found wide application in clinical practice, although the recent introduction of electronic apparatus for progressive current treatments allows this method to be used conveniently in the clinic. Additional advantages of this technique are that progressive currents are well tolerated by patients, and that with the stimulating electrodes placed at the

* Paper read at the Annual Meeting of the British Association of Physical Medicine, April 26, 1958.

† Fellow of the National Foundation, U.S.A.

extremes of a limb such a stimulus can be used to scan that limb for denervation. This is because the denervated muscle will respond at a lower threshold than normally innervated muscle. Again, the accuracy of the technique in the detection of denervation is unknown.

In this paper the use of abbreviated I/T curves and progressive current (P.C.) ratios in the detection of denervation is described. The abbreviation of the I/T curves studied in the case of a high output impedance (constant current) stimulator was the ratio of the threshold intensity for contraction for a 100 millisecond (m.sec.) square pulse stimulus (rheobase) and the threshold intensity for a 1 m.sec. stimulus—i.e. the constant current (C.C.) ratio. In the case of a low output impedance (constant voltage) stimulator the ratio between the threshold intensity at 100 m.sec. and 0·1 m.sec. was studied—i.e. the constant voltage (C.V.) ratio. The P.C. ratio studied was that between the threshold intensity for contraction for a slowly rising (triangle-shaped) stimulus with an ascending limb of 1·5 second duration and decay time of 1 second, and the threshold for a rapidly rising (square pulse) stimulus of 100 m.sec. duration.

TECHNIQUE

This investigation is based on the examination of the muscles of 38 normal controls, 33 patients with peripheral nerve injuries under treatment at the R.A.F. Medical Rehabilitation Unit, Chessington, and 34 cases with chronic neurological lesions attending the Royal Free Hospital. The muscles studied in the cases of peripheral nerve injury were classified into those with complete and those with partial denervation, the muscles in both groups possessing the classical I/T curve corresponding to their state of innervation. Those with partial denervation included some cases in which regeneration was occurring. The muscles studied in cases of chronic denervation were selected by the presence on electromyographic examination of spontaneous fibrillation action potentials in minimal amounts, often found only after a prolonged search. These cases were therefore likely to have minimal denervation and provided a strict test of the accuracy of abbreviated I/T curves in the determination of minimal denervation. The muscles of the polymyositic group were additionally selected by the coexistence of a high rheobase with the fibrillation activity.

Apparatus

For the determination of the 100/1 m.sec. ratio a Bauwens type constant current stimulator (Bauwens, 1941) was used. This delivered an intensity stabilized current which could be varied between 0 and 50 milliamperes (mA) and was supplied from an output impedance of 100,000 ohms or more. For

the estimation of 100/0·1 m.sec. ratios a constant voltage R.A.F. type stimulator (Wynn Parry, 1953) was used which delivered a square pulse of stabilized voltage variable between 0 and 200 volts, constancy being obtained by an output impedance of 500 ohms or less. Both stimulators supplied eight pulse durations—namely, 300, 100, 30, 10, 3, 1, 0·3, and 0·1 m.sec.—the individual pulse having negligible rise and decay time compared with the width. The electrodes used consisted of metal covered with saline-soaked lint; the indifferent electrode measured 3 by 4 inches and was placed proximally over the limb, and the stimulating electrode, of 1 cm. diameter, was placed distally over the muscle. Full I/T curves were plotted on each muscle and were used to confirm the state of denervation in the cases of peripheral nerve injury, the 100/1 m.sec. (C.C.) and 100/0·1 m.sec. (C.V.) ratios then being read from the complete curves.

The electromyograph used was a conventional double-channel electromyograph containing differential two-stage push–pull amplifiers with a linear response from 3 to 5,000 cycles and feeding a cathode-ray tube and loudspeaker. Concentric needle electrodes were used, of 0·6 mm. outside diameter with a silver wire core of 0·2 mm. insulated by a coating of synthetic enamel. Fibrillation potentials were searched for, if necessary, by several insertions of the needle electrode, and neither warming nor electrical or cholinergic stimulation of the muscles was used.

Progressive current ratios were obtained by the use of a modified progressive treatment unit. This modification allowed the equipment to supply a triangle-shaped pulse with the stimulus ascending linearly with time to a maximum at 1·5 seconds and followed by a 1-second decay, this wave form being repeated after a 5·5-second rest period. The impedance output was 500 ohms or less, and the maximum voltage that could be obtained was 105 volts. The stimulus was balanced about earth to avoid ionizing effects. This wave form was used as a stimulus in preference to a saw-tooth pulse in order to allow readings of stimulus intensity at the instant of contraction and at the peak of the wave. It also avoided an unwanted contraction derived from rapid decay of the stimulus. The skin was prepared in every case by cleaning with soap and water followed by the passing of a series of stimuli until minimal threshold intensities were obtained.

RESULTS

In the studies on abbreviated I/T curves no significant difference was noted between the patients' tolerance to the constant current and constant voltage type stimuli. It was observed that the constant current stimulus often

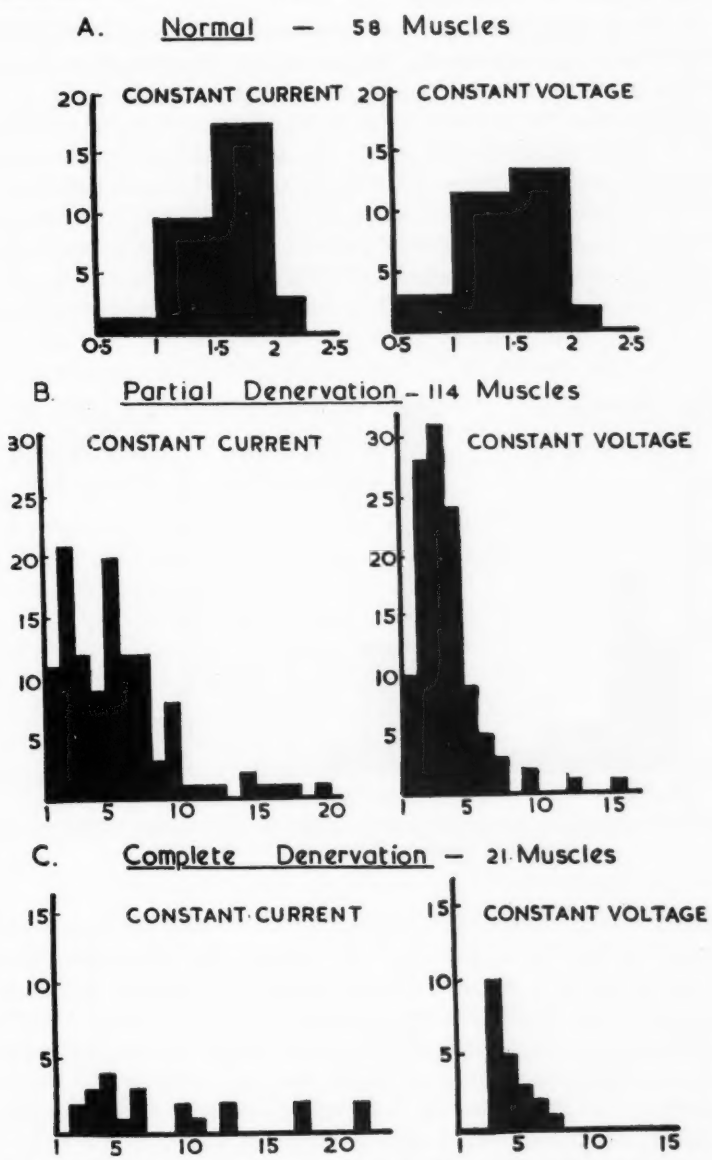

FIG. 1.—Distribution of constant current (100/1 m.sec.) and constant voltage (100/0·1 m.sec.) ratios in (A) normal muscles, (B) partially denervated muscles, and (C) completely denervated muscles. Ordinate=number of muscles; abscissa=ratio.

gave a sharper end-point than was the case with a constant voltage stimulus, and the lowest intensity reading was more rapidly obtained with repetitive stimulation.

Reference to Fig. 1A shows that in the 58 normal muscles all the C.C. and C.V. ratios lie between 1 and 2·2. In the case of C.C. ratios, 3 (5·2%) gave ratios over 2—i.e. two of 2·2 and one of 2·1; and using C.V. ratios 2 (3·2%) did so—one of 2·1 and one of 2·2. All these muscles had smooth-contoured I/T curves. Of the partially denervated muscles that were examined, the most obvious difference between the C.C. and C.V. ratios (Fig. 1B) is the greater scatter in the ratios obtained by the constant current type stimulator—

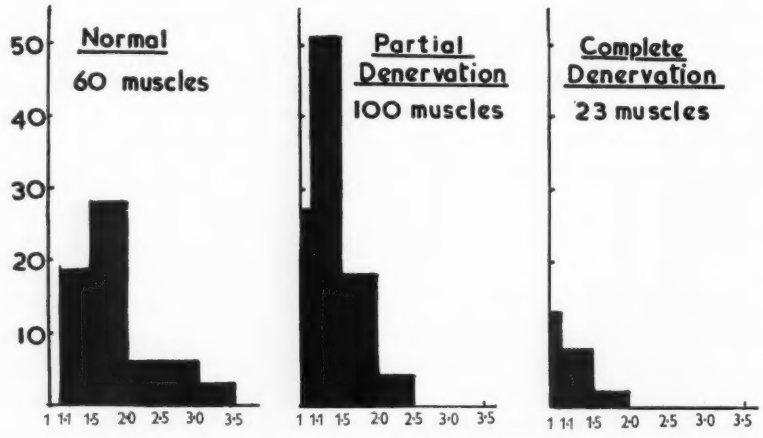

FIG. 2.—Distribution of progressive current ratios in normal and denervated muscles. Ordinate=number of muscles; abscissa=ratio.

i.e. from 1·1 to 20 compared with from 1·4 to 16 with the constant voltage stimulator. Of these 114 muscles, 9 (7·9%) gave a C.C. ratio of less than 2, the figures being two of 1·5, three of 1·6, two of 1·7, one of 1·9, and in one muscle with a low rheobase (2 mA) a ratio of 1·1. The results for constant voltage stimulation were similar, 8 (7%) of the 114 muscles giving ratios of less than 2; these were: two of 1·4, one of 1·5, one of 1·6, one of 1·7, two of 1·8, and one of 1·9. In the case of the 21 completely denervated muscles (Fig. 1C) the C.C. ratios again showed a slightly greater scatter than the C.V. ratios, lying between 2·6 and "infinity" for the former and 3·1 and "infinity" for the latter. "Infinity" denotes a failure to obtain a response at the shorter duration at the upper limit of the stimulator's output. Twenty I/T curves from the

denervated muscles of 14 patients were rejected from the series because of a failure to obtain an end-point for the shorter duration, owing either to the patient's intolerance or to difficulty in determining the end-point because of contractions of the surrounding muscles. In no instance did a completely denervated muscle give by either method a ratio of less than 2·5.

Fig. 2 shows results of the progressive current ratios and indicates a marked overlap between the results obtained from normal and from denervated muscles. Thus, of 60 normal muscles, while the mean ratio was 1·89, the range was from 1·1 to 3·4. For the 100 partially denervated muscles the mean ratio was 1·32 with a range from 1 to 2·5, and in the 23 completely denervated muscles the mean of the ratios was 1·23 but the range from 1 to 1·6. A noteworthy feature was that 5% of patients and 7% of controls were intolerant to the progressive current stimulus. Re-investigation, with a stimulus of even slower rise time, intended to minimize the effect of accommodation of normal muscle, was unsatisfactory on account of intolerance by most of the patients. Difficulty was experienced in defining the end-point in contraction induced with a progressive current stimulus. For these reasons the method was rejected at that stage of the experiment, and the method was not applied to the problem of minimal denervation.

Of the 52 minimally denervated muscles—i.e. muscles in cases of motor neurone disease (26) and peripheral neuropathy (26) with sparse fibrillation potentials—25 (96·2%) of the former and 18 (69·3%) of the latter showed a C.C. ratio of over 2, and 24 (92·2%) of the former and 20 (76·9%) of the latter showed a C.V. ratio greater than 2. Of 16 muscles in cases of dermatomyositis showing scattered fibrillation potentials, 9 (56·3%) showed a C.C. ratio of over 2 and 13 (81%) a C.V. ratio greater than 2. All the 16 muscles in the dermatomyositic group had rheobases above 7 mA current and 35 volts applied potential.

DISCUSSION

The results show a significant error in the use of abbreviated I/T curves in the detection of denervation in peripheral nerve injuries. While on the one hand no normal muscle gave a C.C. ratio greater than 2·2, on the other hand partially denervated muscles sometimes gave a C.C. or C.V. ratio below 2. In contrast to the ratio in partially denervated muscles, completely denervated muscles gave a high ratio which was in no instance below 2·5. It would therefore seem that, if reliance is placed on abbreviated I/T curves and the ratio of 2 is regarded as the significant level, with a constant current stimulator 5% of normal muscles would be regarded as outside normal limits, while 8% of partially denervated muscles would be considered to have normal innervation.

No error would occur in the differential diagnosis of complete denervation and normal innervation, because the ratios would exceed 2·5 in the former and this is outside the range of normal. Using a constant voltage stimulator, approximately 3% of normal muscles would be regarded as denervated and 7% of partially denervated muscles would be regarded as having normal innervation. Again no error would occur in the differential diagnosis of complete denervation and normal innervation. These errors could not be related to the levels of the rheobase or to the presence of regeneration in the peripheral nerve injuries. Because of the method of selection of the muscles examined such errors would be eliminated by the use of full I/T curves and study of the contours of the curves. No significant advantage could be ascribed to either method in terms of patients' intolerance, although it was felt that constant current gave a sharper end-point and constant readings with repetitive stimulation were more rapidly obtained. This would represent a distinct advantage if the technique of testing several points in a muscle were tried instead of a single longitudinal reaction.

The progressive current ratios appear to be of little use in the detection of denervation, for although no normal muscle had a ratio below 1·1 and partially and completely denervated muscles sometimes had low ratios of 1, in the majority of both groups the ratios lie in the range of 1·1 to 2·1. Only in a minority of muscles—i.e. those giving a ratio of 1—could denervation be diagnosed with any certainty. In fact, of 100 partially denervated muscles 27 (27%), and of 23 completely denervated muscles 13 (56·5%), had a ratio of 1. Further, in only a few muscles—i.e. those giving a ratio in excess of 2·5, numbering 9 (15%)—could normal innervation be guaranteed. A surprising finding was that 5 to 7% of subjects found progressive currents painful.

The results obtained from the muscles with minimal denervation derived from chronic neurological disorders reveal some differences in the accuracy of the constant current and constant voltage techniques. While a high percentage of the muscles denervated in motor neurone disease had ratios in excess of 2 by either method, the C.V. ratios were more constantly in excess of 2 in the muscles of the patients with peripheral neuropathy and particularly those with polymyositis. Further, there was a contrast between the accuracy of the abbreviated I/T curves in the detection of denervation in motor neurone disease on the one hand and peripheral neuritis and polymyositis on the other. While the lower incidence of abnormal ratios in the muscles of patients with peripheral neuropathies compared with those obtained in cases of peripheral nerve injury might be expected, in that the former were selected as being minimally denervated, the high incidence of abnormal ratios in the muscles in motor neurone disease is difficult to understand. It is of course well known that in

this disease, which produces slowly progressive denervation, fibrillation potentials are difficult to detect because they are limited to the recently denervated muscle fibres. It may be, therefore, that selection of muscles in motor neurone disease on the basis of minimal fibrillation was not necessarily synonymous with selection of the minimally denervated muscles. While patchy denervation also occurs in polymyositis, in which the inaccuracy in detection of denervation was greatest, here there is the further complication of high rheobases. This factor alone, however, seems unlikely to be responsible for the difficulty in detecting denervation in that higher rheobases in the muscles denervated by peripheral nerve injuries did not affect the accuracy of the technique. A further finding was the greater accuracy of C.V. ratios compared with C.C. ratios in the detection of denervation in polymyositis. Again there is no obvious explanation for this.

The results of C.C. and C.V. ratios in chronic neurological disorders emphasize the importance of using abbreviated I/T curves in conjunction with an additional system of electrodiagnosis, preferably electromyography. By reason of the selection of the cases this series does not allow a comparison of the accuracy of electromyography with that of full I/T curves in the detection of denervation. However, the selection of the cases of peripheral nerve injury on the basis of their I/T curves allows a comparison of the accuracy of full with abbreviated I/T curves in the detection of denervation in that group, and indicates the greater accuracy of the former which allows the contour of the curve to be studied.

SUMMARY

Abbreviated intensity duration (I/T) curves—i.e. constant current (C.C.: 100/1 m.sec.) ratios, constant voltage (C.V.: 100/0·1 m.sec.) ratios, and progressive current ratios (P.C.R.: triangle-shaped pulse and 100 m.sec. square pulse)—were studied in a series of normal and denervated muscles.

With normal innervation the C.C. ratio exceeded 2 in 5·2% and the C.V. ratio exceeded 2 in 3·4% of the muscles tested. Of partially denervated muscles in peripheral nerve injuries, 7·9% gave a C.C. ratio of less than 2 and 7% a C.V. ratio of less than 2. No completely denervated muscle gave a ratio of less than 2·5 with either method. No significant difference was found between constant current and constant voltage techniques in terms of patients' intolerance, but the former was felt to give a sharper and more rapidly obtained end-point.

Progressive current ratios were found to be inaccurate in the detection of denervation from peripheral nerve injuries. Thus, while the ratio approached unity in both partial and complete denervation, the majority of both normal

and denervated muscles had ratios between 1·1 and 2·1. Patient intolerance also reduced the practical value of the progressive current stimulus.

Denervated muscles in chronic neurological disorders gave a lower incidence of C.C. and C.V. ratios greater than 2 than was the case in peripheral nerve injuries. The greatest errors occurred in cases of polymyositis and peripheral neuropathies, and in both these groups C.V. ratios tended to reflect the state of denervation a little more accurately than C.C. ratios.

Acknowledgments

We wish to thank Dr. A. T. Richardson and Squadron Leader C. B. Wynn Parry for their encouragement and help and for allowing us to examine patients under their care. Our thanks are also due to Mr. R. Brennand for his invaluable technical assistance.

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PLATE IV

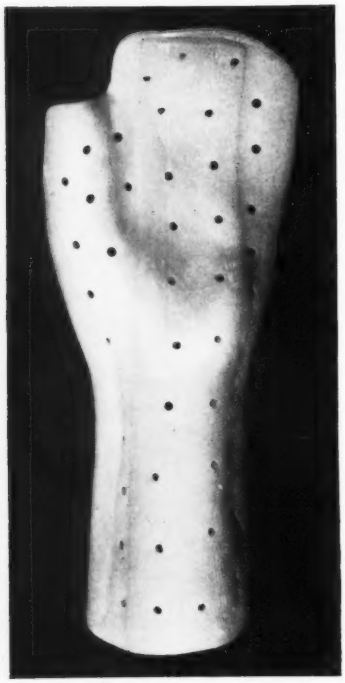

FIG. 1.—Standard wrist and hand splint.

FIG. 2.—Plaster cast for moulding splint.

FIG. 3.—Traction splint for flexion contractures of knee.

FIG. 4.—Splint to show fastenings.

[G.H.D. & T.F. facing page 57

NEW APPLIANCES

USEFUL POLYTHENE SPLINTS

By G. H. DOBNEY and T. FAREWELL

From the Department of Physical Medicine, Whittington Hospital, London

THE standard wrist and hand splint illustrated in Plate IV, Fig. 1, is made on a positive plaster-of-Paris cast (Fig. 2) in two sizes from $\frac{1}{16}$-inch polythene, reinforced with a central strip of $\frac{1}{16}$-inch polythene (Scales, 1950; Brennan, 1954). The lining is of $\frac{3}{16}$-inch Moltopren. When making the plaster mould care should be taken to ensure that the thumb gutter is large enough to accommodate the thicknesses of plastic and the lining material.

These splints supply the need for a light spring support and are useful in a variety of articular and neurological disorders. Once the plaster moulds are cast the splints can be quickly made by a technician, thus resulting in a marked saving of time as compared with splints which are individually moulded by the physiotherapist.

In Plate IV, Figs. 3 and 4, is shown a traction splint for flexion contractures of the knee which is useful where the skin will not tolerate Elastoplast. It is made in one piece of $\frac{1}{8}$-inch polythene approximately 18 inches long and 16 inches wide, reinforced anteriorly, and padded with $\frac{1}{2}$-inch Moltopren which is allowed to project beyond the edges. The posterior V opens out during moulding and leaves the heel uncovered. It is fastened with three straps surrounding the calf and two surrounding the foot, and a band of 2-inch webbing riveted along either side of the leg, with a wooden spreader the width of the angle to which the traction cord is attached. The splint fits loosely, and need not be individually moulded in the majority of cases.

ACKNOWLEDGMENTS

Our thanks are due to Mrs. E. I. Benady, M.C.S.P., who made the splints, and to Miss E. Mason, of the photographic department, St. James's Hospital, Balham, for the photographs.

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REVISION SERIES

PAIN IN THE FOOT AND HEEL

By A. T. RICHARDSON

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PAIN in the foot or heel is one of those common and troublesome symptoms which, while occasionally indicative of systemic or other serious disease, is usually derived from benign and often ill-defined lesions. Because such lesions produce few clinical or radiological signs diagnostic confusion exists; and because in most cases the pain is self-limiting, albeit subject to relapse, an extraordinary number of treatments have gained a spurious reputation for effectiveness.

In this paper the causes of chronic or recurrent pain in the foot and heel are reviewed with particular reference to lesions which may accompany generalized disease of the locomotor or other systems.

PRINCIPLES OF DIAGNOSIS AND MANAGEMENT

The diagnosis of foot and heel pain depends essentially on its localization. Fortunately, patients can usually point to the site of a lesion even when it is deep-seated. It is noteworthy that pain is hardly ever referred to the foot only, but is felt diffusely over the lower part of the limb. A painful lesion in the foot may, however, produce a disorder of function and secondary pain, so disguising the original lesion—for example, pain is commonly complained of over the fourth and fifth metatarsal heads following the redistribution of weight-bearing to avoid pain from osteoarthritis of the first metatarso-phalangeal joint. Apart from patients' ability to localize a lesion, the history offers little help. Thus the pain is usually worse on weight-bearing and is seldom characteristic, except perhaps in terms of the contrast between the acute stabbing pain of a nipped digital nerve and the burning pain of diabetic peripheral neuropathy or of erythromelalgia, and the relation of claudication pain to exercise.

Localization of painful lesions in the foot by clinical examination requires not only a search for tenderness and inspection of the foot for deformities, but also the testing of passive mobility of the joints, inspection of shoes for excessive wear, and examination of the foot during weight-bearing. Further, diagnosis of a painful foot may demand the fullest examination, with particular reference to the locomotor, central nervous, and vascular systems. Radiological examination is an essential in that it may be the only method of revealing bone and joint lesions, the presence of which may call for pathological investigations.

The principles of the management of the painful foot are three, except where specific treatment exists, as in the case of a tuberculous foot joint. They are: (1) restoration of full mobility where possible, for it is a fact that a supple foot is seldom painful, whereas a rigid foot generally is; (2) restriction of foot movements within the painless range by orthopaedic supports; and (3) attempts to redistribute weight-bearing by supports or surgery. Heat and massage have no place in the management of the painful foot, although, like other forms of physiotherapy, they occupy the patient and satisfy him that something is being done. Faradic stimulation of the small muscles of the foot is of dubious value, although in combination with foot exercises it may help to maintain mobility and induce the use of the interosseous muscles in a splayed foot. Foot exercises designed to strengthen the muscles supporting the arches of the foot are also of doubtful value, but that they have a place in the establishment of postural and walking re-education is generally agreed.

PAIN IN THE FORE-FOOT

The key to the diagnosis and, indeed, management of pain in the fore-foot is an understanding of the relation of such pain to deformity. It cannot be over-emphasized that foot deformities are by no means always associated with pain and that pain may be unrelated to any existing deformity.

Pain Associated with Foot Deformities

PES VALGUS

Children seldom suffer from painful feet, but are often found to have "deformed" feet. Thus, except for skin lesions and such readily recognizable lesions as osteochondritis of the navicular, calcaneus, or metatarsal bones, the majority of children seen in physical medicine departments with complaints referable to the feet suffer from no more than parental interest in their offspring's "flat feet" (pes valgus). These are more often than not physiological, or will become so by the time the child is 7 or 8 years old (Morley, 1957). This deformity may, however, be part of a general postural defect, compensatory to a short tendo Achillis, obliquity of the lower tibial epiphysis, or rotation of that bone. When pain occurs in simple pes valgus it takes the form of aching at the end of the day, after walking, or when standing for long periods in slippers or sandals. Thus nothing more is indicated than advice to the parents on suitable footwear. When, however, the pain is persistent, and particularly if the heels of the shoes show excessive wear on the inner side, a heel wedge of $\frac{3}{16}$ inch should be attached inside the shoe. Leather stiffening to support the instep is a useful addition to prevent distortion of the upper part of the shoe. An exception

to the use of a heel wedge inside the shoe is in the rare case where a child with severe flat-foot wears down the heels of his shoes on the outer side. This is due to the child's efforts to maintain the arches of the foot when walking; indeed, such children generally show persistent intoeing. Raising the inner side of the heel in these cases makes the gait worse, and the best treatment is by a valgus insole (Sharrard, 1958).

The importance of restoring and maintaining the mobility of the feet has already been emphasized, and this applies particularly to children. For the relief of painful or, rather, aching "flat feet" when they have persisted into adult life or have developed in association with obesity or occupational strain mobilization and supportive treatment (see under "Chronic Foot Strain") are indicated.

In adolescents, and occasionally in younger children, spasmodic flat-foot (peroneal-extensor spasm) is a well-recognized syndrome. In this disorder the foot is held in a position of valgus by spasm of the peronei and the long extensors of the toes. The spasm is apparently of reflex origin, and, while its aetiology is not fully understood, a lesion of the talo-calcaneal ligament or mid-tarsal joint is sometimes the cause. Patients with spasmodic flat-foot complain of pain, particularly on changing to an occupation involving standing or walking on a hard surface. On examination any attempt to invert the foot passively will increase the pain. A plaster applied to the foot in the neutral position and prohibition of weight-bearing for a period may relieve the pain, and success has also been claimed for the injection of local analgesic into the talo-calcaneal ligament. However, in the last resort a number of these patients are subjected to operations aimed at stabilizing the foot—for example, fusion of the talo-calcaneal and talo-navicular joints (Wiles, 1955).

PES CAVUS

Pes cavus, which in most instances is accompanied by clawing of the toes, derives from dysfunction of the interossei, the lumbricals, and the short flexors and abductors of the first toe. Such dysfunction, while usually arising from simple incoordination of these muscles (so-called idiopathic pes cavus), may be due to neurological lesions, notably acute anterior poliomyelitis, peripheral nerve lesions, Charcot–Marie–Tooth disease, Friedreich's ataxia, and their variants. In patients with nerve lesions the deformity is often asymmetrical and is usually accompanied by additional neurological signs. This group, with the exception of those with spastic paraparesis, are readily distinguished by the presence of electrodiagnostic signs of denervation in the small muscles of the feet. The common idiopathic type generally arises in childhood, and is seldom accompanied by pain until adult life. Eventually, however, pain due to abnormal

pressure on the ball of the foot arises and callosities develop under the metatarsal heads. Finally the deformity tends to become fixed and shoes have to be designed to give maximum comfort—that is, to supply ample room for the deformed toes with a thick insole to fit the high instep. Surgery aimed at correcting the muscle imbalance by arthrodesis of the interphalangeal joints and so allowing the long flexors to flex the toes at the metatarso-phalangeal joints (Lambrinudi's operation) may be indicated.

HALLUX VALGUS AND RIGIDUS

Hallux valgus is by far the commonest foot deformity; it may be familial, women being afflicted more often than men. While the cause is debatable, it is usually blamed on tight or pointed shoes, though the only convincing evidence of this is that it is uncommon in barefoot races. The result of the lateral deviation of the phalanx at the first metatarso-phalangeal joint is the formation of an exostosis and adventitious bursa on the metatarsal head (bunion) and eventually degenerative changes in the joint. Conservative treatment consists in padding to protect the bunion and a domed metatarsal bar to overcome the secondary anterior metatarsalgia. Surgery in the form of simple excision of the bunion and underlying exostosis may suffice, but the more radical Keller's or Mayo's operation is more successful. Hallux valgus is peculiarly common in adolescent girls, and, while generally symptom-free and calling for no more than advice on footwear, it occasionally gives rise to pain in the first metatarso-phalangeal joint. Hallux rigidus may follow trauma in adolescents, but is more common in adults, when it is frequently bilateral and the underlying pathology is that of osteoarthritis. In many of those who develop hallux rigidus in adolescence the foot is so shaped that the first metatarsal is hyperextended (Jack, 1940), thus throwing more weight on the big toe and leading to degenerative changes in the metatarso-phalangeal joint. Treatment of both conditions is by stiffening the shoe beneath the first metatarso-phalangeal joint, a metatarsal rocker and, if necessary, arthroplasty of the joint.

OTHER DEFORMITIES

In hammer-toe deformity there is hyperextension at the metatarso-phalangeal joint with flexion at the proximal and flexion or extension at the distal interphalangeal joints. A painful corn or bursa invariably develops over the prominent proximal joint. When the deformity occurs in isolation a felt pad may relieve the pressure, and where this fails Higgs's spike operation gives good results.

Congenital shortness of the first metatarsal is a deformity which has perhaps received undue emphasis in the past. In the normal foot the thick,

slightly longer first metatarsal, under whose head lie one or two sesamoid bones, is better equipped as a fulcrum for take-off in walking than the lateral metatarsals. When, however, the first metatarsal is short and the head of the second projects beyond the other metatarsals, the second metatarsal is subjected to greater strain, and this may predispose to march fracture (see below) and to anterior metatarsalgia. Anterior metatarsalgia—that is, pain affecting one or more of the outer four metatarso-phalangeal joints—appears typically in middle age and is usually caused by abnormal distribution of weight on the fore-foot associated with a splayed foot, the outer metatarsals being ill adapted for weight-bearing. A further precipitating factor is an abnormal position of the metatarsals and proximal phalanges due to muscle imbalance or faulty footwear (Craigmile, 1953). Correction of the weight-bearing by supports and remedial exercises is the obvious remedy.

Chronic Foot Strain

Foot deformities, by creating abnormal strains, predispose to so-called chronic foot strain, from which by far the greatest number of patients with painful feet suffer. This condition may, and often does, occur in the absence of deformity. The main feature of this syndrome is lack of the usual resilience of the foot, in particular an inability of the foot to rotate into a valgus position on static weight-bearing. It is important to recognize that the natural mobility of the foot, as is well exemplified in barefoot races and ballet dancers, allows it to be almost completely flat when weight-bearing in the relaxed position, and highly arched in action from the pull by the muscles. Constrictive footwear, by its splinting effect, gives rise to relative rigidity of the longitudinal arch (Lake, 1943). This rigidity may be accentuated by deformity, trauma, or hypostatic oedema, and in feet so afflicted tension on any shortened ligaments, joint capsules, or adhesions gives rise to pain. While this pain is initially localized to the inner border of the foot and is, of course, produced by weight-bearing, it eventually radiates widely over the foot and calf and becomes more constant. The essential feature disclosed on examination is limitation of passive movements with pain at the extreme of movements. Treatment should take the form of either supporting the foot within its painless range by arch supports, thus preventing the tension on the ligaments, or preferably of manipulation and exercises to restore mobility, or both.

Pain Unassociated with Foot Deformity

In the absence of deformity and of immobility of the foot giving rise to pain, diagnosis depends on localizing pain and tenderness to the various structures of the foot and consideration of their possible lesions. Diagnosis of joint lesions

depends on the demonstration of restriction of passive movements of a suspected joint with radiological and pathological confirmation. The joints of the foot may be the seat of any of the more common lesions, such as strains or those due to rheumatoid and degenerative arthritis. Tuberculosis of a joint and, indeed, calcaneal tuberculosis and infantile tuberculous dactylitis are rare; however, the majority of chronic infections of the feet, apart from those following penetrating injuries, are due to these causes. Involvement of a particular joint may, of course, suggest the form of arthritis. Thus gout commonly involves the much-traumatized first metatarso-phalangeal joint, and the mid-tarsal joint is not uncommonly involved in both osteoarthritis and rheumatoid arthritis. A noteworthy feature is that the proximal and distal interphalangeal joints are seldom involved in typical rheumatoid arthritis, and when this does occur signs of psoriasis (Plate V, Fig. 1), ulcerative colitis, or Reiter's syndrome should be sought (Bywaters, 1958). Lesions of the metatarso-phalangeal joints may be due to rheumatoid arthritis, but are generally associated with splayed foot. Big-toe metatarsalgia usually arises from traumatic lesions of the sesamoid bones lying under the metatarso-phalangeal joint and may be relieved by padding.

In considering pain in relation to the bones of the foot the not uncommon march fracture must be borne in mind. This condition, for which bone fatigue has been held responsible, generally occurs in the absence of trauma. Clinically it is characterized by localized tenderness, warmth, and oedema over the affected metatarsal neck. Radiological confirmation may be difficult in the first two weeks because displacement does not occur and the fine crack in the bone may be almost invisible, but it is readily obtainable once callus has formed (Plate V, Fig. 2). March fractures recover spontaneously within six weeks.

The osteochondropathies of children are well known, important examples being Köhler's osteochondritis of the navicular (Plate V, Fig. 3) and Freiberg's osteochondritis of the head of the second metatarsal.

Involvement of the peripheral nerves of the foot is not uncommon, well-known examples being the painful burning foot of diabetic and alcoholic peripheral neuropathies and the localized agonizing pain which characterizes Morton's metatarsalgia. The latter condition is due to pressure of the fourth metatarsal head upon the communicating branch between the third and fourth plantar digital nerves, leading to the development of a traumatic neurofibroma. Diagnosis depends on the history of severe momentary pains in the fore-foot, sometimes preceded by a burning or tingling sensation, which necessitate relief from weight-bearing. There are no physical signs and, as conservative treatment nearly always fails, excision of the nerve concerned should be undertaken. Tabetic and nerve-root pressure pains seldom involve the foot alone.

Obliterative arterial disease producing intermittent claudication of the small muscles of the foot is a diagnostic trap, particularly as, like claudication of the buttock, it is not so well known as that affecting the calf muscles. The diagnosis depends on the typical history of pain on walking relieved on resting, with perhaps evidence of arterial disease elsewhere. The pain of erythromelalgia is easily recognized in that it is generally induced by warmth and accompanied by such vascular phenomena as flushing, heat, and pulsation.

PAIN IN THE HEEL

Pain in the heel can be conveniently divided into pain under the heel and pain behind the heel, to which areas it is readily localized by afflicted patients.

Pain under the Heel

Lesions of the body of the calcaneum are readily diagnosed on their X-ray appearances. In general, such lesions produce pain which is aggravated by weight-bearing. Clinically, there is tenderness on pressure on the plantar aspect of the bone and on lateral pressure. Deformity may occur. Examples are calcaneal fractures, Paget's disease, and such rarities as melorheostosis. While Paget's disease in the calcaneum usually occurs in association with the disease elsewhere, it may be localized to this bone (Brailsford, 1951). A useful diagnostic feature is that pain is complained of at night in addition to pain on or after weight-bearing. The early X-ray appearance of striation in the bone is also of diagnostic value (Plate VI, Fig. 1). Less well known as a cause of painful heel is post-traumatic osteoporosis of the os calcis and small bones of the foot. This condition, essentially comparable to Sudeck's atrophy of the hand, may follow trivial injury and, like other of the so-called reflex sympathetic dystrophies, usually remits within two years. Mention must also be made of the painful heel following traction on the calcaneum by a Kirschner wire. Apart from fractures and infections, no specific treatment exists for lesions of the calcaneum, but symptomatic relief is often obtained by protection with Sorbo rubber or felt pads.

The spur on the under side of the calcaneum which is frequently seen on lateral radiographs was formerly regarded as a common cause of heel pain and sometimes removed, often with disastrous results. In fact this appearance may be found on radiographs of painless heels, and it is generally agreed that it usually only indicates that there is or has been a chronic strain of the plantar fascia. It appears to be due to ossification in that structure, and as such must not be confused with the bony reaction of the os calcis typical of ankylosing spondylitis or Reiter's syndrome (Plate VI, Fig. 2). A history of painful heels accompanying iritis and intermittent large joint effusions in young men should

PLATE V

FIG. 1.—Psoriatic arthropathy.

FIG. 2.—March fracture of second metatarsal.

FIG. 3.—Osteochondritis of navicular bone.

FIG. 1.—Paget's disease of calcaneum.

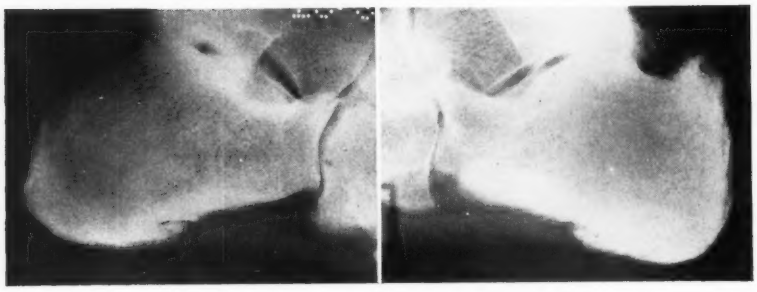

FIG. 2.—Heels in ankylosing spondylitis.

FIG. 3.—Calcaneal erosions in rheumatoid arthritis.

lead to a suspicion of ankylosing spondylitis, to exclude which X-ray examination of the sacro-iliac joints is necessary. The painful heel of ankylosing spondylitis, like other manifestations of this disease, usually responds to X-ray therapy. Rheumatoid arthritis similarly may affect the heel, producing plantar erosions of the os calcis, the basic pathology being invasion of the bone by fibrinoid-containing tissue resembling a rheumatoid nodule.

PLANTAR FASCIITIS

The commonest cause of pain under the heel is plantar fasciitis. This produces a well-defined clinical picture of pain under the heel in the short, stocky, heavily built type of male, accompanied by tenderness localized to a small area about 2 inches in front of the point of the heel on the postero-medial aspect. Plantar fasciitis is generally considered to be comparable to tennis elbow, and to be derived from fibrosis in the plantar fascia occurring secondary to collagen degeneration in this tissue, to trauma, or possibly to infection. Infection, particularly by the gonococcus, has in the past had an undeserved reputation as a cause of painful heels; the gouty diathesis has also been inculpated. Plantar fasciitis, like tennis elbow, clears up sooner or later, but seldom lasts more than 18 months. A great number of treatments have been tried, none of which are of proven value with the exception, perhaps, of the fitting of an insole (Rose, 1955). This should be designed to raise and tilt the heel, put the foot in a cavus position, and so relax the plantar fascia at its attachment medially to the vertical axis of the peritalar joint (Shephard, 1951). Protection with a Sorbo rubber pad and gouging out a hollow in the heel of the shoe is a poor substitute, but a length of strapping between the heel and toes holding the foot in a cavus position can be remarkably effective (Woolnough, 1954). The effectiveness of local hydrocortisone in such lesions as tennis elbow and supraspinatus tendinitis has tempted some to use this form of treatment in plantar fasciitis. Blockley (1956), however, failed to demonstrate any difference between two groups treated respectively with hydrocortisone and with injections of normal saline. Further, an exacerbation of pain for some two or three days after an injection of hydrocortisone has been known to occur. The clinical entity of the painful heel suffered by tennis players at the beginning of the season, and similarly deck heel and guardsman's heel, are probably variants of plantar fasciitis. Repeated trauma is clearly of aetiological significance in this group, and the localization of the tenderness suggests that the lesion is in the posterior insertion of the plantar fascia.

A condition that is commonly confused with plantar fasciitis is the painful heel after recumbency. This is well known in surgical wards, and is typified by the patient shuffling around in heelless slippers for the first few days of weight-bearing after prolonged recumbency, particularly if due to debilitating illness.

Fortunately it remits in a few days, particularly if the patient is encouraged to wear proper shoes and place his full weight on his feet.

Pain Behind the Heel

Pain behind the heel may be similarly described in terms of clear-cut clinical syndromes. Apophysitis of the calcaneum (Sever's or Haglund's disease) in children between 8 and 14 years of age is a well-known example. The pain is typically over the point of the heel, with tenderness over the postero-inferior edge of the os calcis. The process is similar to that of osteochondritis juvenilis in other parts of the body. Pain from this source disappears within a few months, and no treatment beyond reassurance of the parents and the wearing of supporting pads is indicated. Posterior calcaneal erosions, which occur in 2% to 3% of rheumatoid arthritics (Bywaters, 1954), are most commonly situated in the area 2 cm. below the upper surface of the os calcis in relation to the insertion of the tendo Achillis (Plate VI, Fig. 3).

Tenosynovitis affecting the sheaths of the tibialis posterior, flexor digitorum longus, or flexor hallucis longus on the medial aspect of the ankle, and of the peroneus longus or brevis on the lateral aspect, is familiar to most physicians, though it is not very common. Diagnosis depends on demonstrating pain on use of the affected muscle, crepitus, and localized swelling. Treatment for non-infective tenosynovitis in this area—and this is the usual type—is by immobilization and/or local hydrocortisone injection; and for the infective types, specific treatment of the infection.

Less well recognized is involvement of the sub-Achilles bursa—so-called achillodynia—in rheumatoid arthritis, or more commonly in ankylosing spondylitis or Reiter's syndrome. Inflammation of this bursa, which lies between the Achilles tendon and the os calcis, causes swelling with tenderness on lateral pressure deep to the Achilles tendon. Sub-Achilles bursitis may follow unaccustomed exercise—e.g. after a cross-country run; but it may also be a presenting sign of arthritis. It then characteristically gives rise to associated erosions of the os calcis or a periosteal reaction. It is readily treated by aspiration of the bursa and injection of hydrocortisone, or, if persistent, by surgical resection. Calcification is sometimes seen in the sub-Achilles bursa, but is commonest in the Achilles tendon itself. Here its cause is unknown, but it seems likely that it arises in similar fashion to supraspinatus calcification—that is, from degenerative changes. The Achilles tendon sheath may develop tenosynovitis, and the tendon itself, like the supraspinatus tendon, is subject to rupture. This causes sudden pain in the heel, with inability to stand on the toes, of one foot. In diagnosis the demonstration that dorsiflexion of the foot is increased on the side of the rupture is confirmatory.

The tendo Achillis is protected by an overlying bursa which, like other similar structures, may be involved in gout. It is also a well-known source of pain in young women, particularly nurses. This is caused by pressure between the shoe and a prominent lateral tubercle of the os calcis, to which the tenderness is localized. It is relieved by padding, but may necessitate surgical removal of the postero-superior angle of the os calcis.

For the sake of completeness painful lesions of the skin of the foot and heel —e.g. warts, embedded foreign bodies, etc.—and nail lesions—e.g. ingrowing toenail, subungual exostosis, etc.—must be mentioned. Neither the diagnosis nor the treatment of these groups of lesion presents any difficulty, and no further discussion is necessary.

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BOOK REVIEWS

TEXTBOOK OF ORTHOPAEDIC MEDICINE. Vol. I. DIAGNOSIS OF SOFT TISSUE LESIONS. By James Cyriax, M.D.(Cantab.), M.R.C.P.(Lond.). *3rd edition. Pp. 711; 36 plates, 131 illustrations. 45s. London: Cassell. 1957.*

Practitioners of physical medicine will welcome the third edition of Dr. Cyriax's well-known textbook. Its undoubted value lies in the clear and detailed description of the author's method of examining the locomotor system and localizing the various lesions of soft tissues. Experienced practitioners will question the author's interpretation of the pathology of some of the lesions he describes, and doubts will be accentuated by the tendency to dogmatize on the prognosis and treatment of disorders which have long been, and still are, subjects of controversy.

Although the subtitle of this book is "Diagnosis of Soft Tissue Lesions", the treatment of the many conditions described is considered in outline or detail, including the indications for, and effects of, manipulation and deep massage, the techniques of which are dealt with in the companion Volume II. The author's intention appears to be that the larger Volume I should deal with diagnosis and the aspects of treatment which are the concern of doctors, whilst the smaller Volume II should deal with the detailed techniques of manipulation and deep massage which are carried out by physiotherapists. However, doctors want to know about techniques if they are going to prescribe them for their patients, even though they may not carry out the treatment themselves. Likewise, physiotherapists are interested in pathology and alternative methods of treatment. Medical readers will find the frequent cross-reference to Volume II irritating, and it is doubtful whether it is of much value to the physiotherapists to have certain, but not all, of the methods they use in the treatment of soft-tissue lesions dealt with in a separate volume. Since the diagnosis and treatment of lesions affecting the soft tissues of the body are in both volumes dealt with by regions, starting with the head and neck, upper limbs, trunk, and lower limbs, it would be an advantage if the subject-matter could be brought together in a single textbook.

One of the best features of this book is the clear text broken up by numerous subtitles. Concise presentation makes for easy reading, and the plates and illustrations are of a high standard.

F. S. COOKSEY

PERIPHERAL NERVE INJURIES. By Ruth Bowden. *Pp. 60. 8s. 6d. London: H. K. Lewis. 1958.*

This book gives a good outline of the practical approach to the diagnosis and treatment of peripheral nerve injuries. It does not pretend to be more than an introduction to the subject, and is designed to supply the needs of physiotherapists, medical students, and housemen. That the need for such a book exists is obvious, and, aided by good diagrams, this book goes far to meet this requirement.

At the beginning of the book there is a good, simple, yet comprehensive classification of the causes of peripheral nerve lesions, and this is followed by an adequate explanation of the processes involved during nerve damage and regeneration.

In view of the fact that this book is designed for physiotherapists and students, it is perhaps a pity that such terms as Tinel's sign are not explained in greater detail, and that the differentiation between anaesthesia and analgesia, occurring in relation to the diagrams, is not made clearer. The chapter on electrodiagnosis is a good,

concise summary of the simpler methods used, and the following chapter on anatomy is excellent.

A minor criticism of wording is perhaps permissible in Chapter V on page 44, where we find that during an operation "the nerve should be exposed and cut cleanly with a razor blade." Later in this chapter there is a minor contradiction in that on page 45 it is suggested that an important aspect of treatment in peripheral nerve injuries is that the reduction of dislocations and fractures and the exploration of wounds should be carried out as soon as possible, yet on page 48 it is suggested that primary suture is *not* the method of choice.

The excellence of this little book is proven by the fact that only minor criticisms can be levelled against it. It can be thoroughly recommended as a guide to physiotherapists and medical students, and could be read with benefit by physicians whose contact with peripheral nerve injuries is but infrequent. NEIL CARDOE

PHYSIOTHERAPY IN SOME SURGICAL CONDITIONS. By Joan E. Cash. *2nd edition. Pp. 362. 25s. London: Faber and Faber. 1957.*

In this book the author sets out to describe the surgical conditions which entail the use of physical measures in treatment. A brief account of the applied anatomy and surgical pathology of these conditions is included, and a more detailed account of the complications. The rationale of physiotherapy in each condition is discussed. The book is a topical and comprehensive survey of the subject. There are three chapters devoted to each of thoracic surgery and neurosurgery, and a generous section on fractures. The author states in the preface that it is not intended that specific techniques of physiotherapy should be included.

To make for easier reading each chapter is divided into subheadings. It might be thought that occasionally the amount of space devoted to topics is disproportionate; for example, the aetiology of gravitational ulcers is dismissed in a few lines, while several pages are devoted to the anatomy of the ear.

Although this is an excellent book which fulfils a necessary requirement, the standard of the illustrations falls greatly below that of the written content. The lumping together of seemingly random photographs at the beginning of the book, and the paucity of line drawings in the text, must be criticized. Better selection and arrangement of illustrations would make for easier reading and fuller comprehension. Nevertheless the book will be of value to both the student and the qualified physiotherapist.
HÉLÈNE V. GOODMAN

PROGRESSIVE EXERCISE THERAPY IN REHABILITATION AND PHYSICAL EDUCATION. By John H. Colson. *Pp. 184. 18s. 6d. Bristol: John Wright. 1958.*

This is a simple, straightforward account of active exercises and of methods of progressing them. The line drawings are clear and well illustrate the text. I could wish there were two extra chapters—one devoted to remedial games, for formal exercise can become boring; and the other on exercises suitable for a remedial pool. The specific exercise schemes make a good framework for planning schemes of exercises for individual patients with the conditions mentioned.

This book will be useful to all who are concerned with exercises as a means of restoring and maintaining physical function. A. P. H. RANDLE

REHABILITATION OF THE HAND. By C. B. Wynn Parry. *Pp. 273. 45s. London: Butterworth. 1958.*

This is a unique book in that, for the first time, an attempt has been made to describe in the greatest detail the various measures which are used to restore the disabled hand to fullest function. It is clear that a great deal of experience, gained mainly in the Royal Air Force, lies behind the author's description of the techniques used.

The book starts with a good practical outline of the functional anatomy of the hand, and subsequent chapters describe injuries to tendons, peripheral nerve lesions, and stiffness of the hand as a result of injury or disease. There is a particularly good chapter on electrodiagnosis, dealing in turn with both strength–duration curves and electromyography. That the chapter on the rheumatoid hand and its management does not come up to the standard of the rest of the book is, perhaps, a reflection of the excellence of the other chapters.

The largest chapter is devoted to techniques of treatment, and includes a very useful section on the use of splints and plaster technique, and, as in the rest of the book, illustrations are of high standard and serve to emphasize important points in the text.

There is no doubt that this book fills a gap in the literature, and that it should be of great value to all whose particular interest lies in the after-care of the patient.

A. C. BOYLE

ORTHOPAEDICS IN GENERAL PRACTICE. By W. H. Gervis. *Pp. 120. 10s. 6d. London: Heinemann (Medical Books). 1958.*

This excellent little book is written for the general practitioner by an orthopaedic surgeon who has had experience in general practice. In five chapters the author deals with the neck and upper extremity, backache, treatment of minor injury, the foot, and finally gives his conclusions.

It is surprising that hydrocortisone is not mentioned in the treatment of tennis elbow. In the chapter on backache, not all will agree with the author's view that, after removal of a plaster jacket for a prolapsed intervertebral disk, a corset is unnecessary and harmful. The chapter on the foot is clearly written and well illustrated.

Mr. Gervis, in his conclusions, so rightly stresses how physical training instructors could assist in the prevention of back troubles in later life, by not forcing a child to touch its toes with the mistaken idea that this stretched short hamstrings.

DOUGLAS L. WOOLF

ABSTRACTS OF THE LITERATURE

Clinical Diagnosis of Systemic Lupus Erythematosus. R. ARMAS-CRUZ, J. HARNECKER, G. DUCACH, J. JALIL, and F. GONZALEZ. *Amer. J. Med.*, 1958, **25**, 409.

The clinical diagnosis of systemic lupus erythematosus is discussed on the basis of 108 cases seen by the authors.

The onset of the disease may be acute or very insidious. Constitutional disturbance occurs in 100% of patients, and joint symptoms simulating rheumatoid arthritis in 91%. Other manifestations may be cardiac, cutaneous, gastro-intestinal, serosal, lymphatic, pulmonary, mental, neurological, or vascular.

A positive L.E.-cell phenomenon was found in 90·4% on examination of the centrifuged clot of peripheral blood. The authors consider that there is no correlation between the presence of L.E. cells and prognosis; no cells were found in several severe and fatal cases. Other haematological findings may be anaemia, absolute or relative leucopenia, and thrombocytopenia. The E.S.R. was raised in 94% of cases. The total protein content may be normal, or slightly diminished with an increased globulin and decreased albumin content. Hyperglobulinaemia is the most characteristic change, usually gamma globulin being increased.

Renal involvement is an important diagnostic feature, protein, cells, and casts being found in the urine.

Several features are stressed that have not appeared in other reports: certain skin lesions, "lupus hair", chemosis, bilateral pleurisy, dyspnoea *sine materia*, and "summer Raynaud's phenomenon".

MAURICE F. HART

Systemic Lupus Erythematosus. G. D. COPELAND, D. VAN CAPELLER, and T. N. STERN. *Amer. J. med. Sci.*, 1958, **236**, 318.

This is a clinical report of 47 cases of lupus erythematosus with pathological findings in 18. The type and the age of onset, clinical features, and pathological findings are tabulated. Of the patients 85% were negroid, corresponding to the percentage of negroes in the sample of population studied. The findings did not differ from those in previous series, except that skin hyperpigmentation was more frequent than usual. Cardiovascular complications were more common in the present series. It is suggested that these differences are probably related to the high proportion of negroes in the series.

G. O. STOREY

Neurological Syndromes Associated with Carcinoma. SIR RUSSELL BRAIN and R. A. HENSON. *Lancet*, 1958, **2**, 971.

Carcinomatous neuropathy can be classified as follows: neuromuscular disorders, cortical cerebellar degeneration, mixed forms, sensory neuropathy, and peripheral neuropathy. Out of a series of 43 cases seen by the authors, the lung was the site of the underlying carcinoma in 32 cases.

Mental disturbances occur in the absence of intracranial secondary deposits; there may be toxic confusional psychosis or agitated depression leading to dementia.

The differential diagnosis and theories of causation are discussed.

MAURICE F. HART

Trochanteric Syndrome. M. H. LEONARD. *J. Amer. med. Ass.*, 1958, **168**, 175.

This short paper reviews the problem of tendinitis and bursitis in the region of the greater trochanter, with and without calcification. The two conditions are described, and compared with similar lesions around the shoulder-joint. Good results have been obtained with injections of hydrocortisone.

D. A. BREWERTON

Familial Osteoarthropathy of the Fingers. A. C. ALLISON and B. S. BLUMBERG. *J. Bone Jt Surg.*, 1958, **40B**, 538.

The authors describe a genetically determined abnormality of the hands characterized by enlargement and loss of mobility in the proximal and distal interphalangeal joints which develops in childhood, is probably due to avascular necrosis of the epiphyses, and in later life appears clinically and radiologically to resemble chronic arthritis. Seventeen affected members of two families originally living in Gloucestershire and Berkshire were examined, but other members of the family were thought to be affected, and it appeared that where one parent was affected 50% of the children developed the condition. The sex incidence

was equal. Occasionally other joints are also affected, including the interphalangeal joints of the feet and the hip-joint. Despite the early age of onset and marked radiological changes, disability was usually slight.

This condition should be distinguished from osteoarthritis, rheumatoid arthritis, and gout by its early age of onset, equal sex incidence, benign course, characteristic joint distribution, and familial incidence.

[It is probable that this and allied conditions are seen from time to time in physical medicine clinics. Anyone interested should read the original article.]

S. MATTINGLY

The Value of Intra-articular Injections in Osteoarthritis of the Knee. J. H. MILLER, J. WHITE, and T. H. NORTON. *J. Bone Jt Surg.*, 1958, **40B**, 636.

This paper from Glasgow describes a careful, controlled investigation of the effect of intra-articular injections on primary osteoarthritis of the knee-joint. Three solutions were studied: lactic acid and Novocain (*p*H 5·7), Novocain (2%), and hydrocortisone (25 mg.). Normal saline and mock injections served as controls. The study was carried out as a "double blind" experiment and techniques were standardized. Of 202 patients injected, 181 were followed up at six weeks and 137 at six months.

Although intra-articular injections appeared to influence the behaviour of the joints, there was no significant difference in the effects demonstrated in the results, irrespective of the injection used, including the controls. The place of injection therapy is discussed and attention is drawn to the psychological implications.

P. J. R. NICHOLS

Phenylbutazone in the Treatment of Temporal Arteritis. S. E. BJORKMAN. *Lancet*, 1958, **2**, 935.

The author describes the treatment with phenylbutazone of eight patients with temporal arteritis. Relief of symptoms was obtained in all cases as rapidly as with steroids. Pain and fever were relieved, but the erythrocyte sedimentation rate and electrophoretic pattern of the plasma proteins remained abnormal. The effect of the drug, therefore, seems to be symptomatic, but, in view of the known effect of phenylbutazone on thrombophlebitis, there may be a direct anti-inflammatory effect on the wall of the vessel.

G. O. STOREY

Surgical Collapse During and After Corticosteroid Therapy. *Brit. med. J.*, 1958, **2**, 935.

This article is based on a lecture to the Faculty of Anaesthetists, and provides an excellent review of the situation, although it does not add any new clinical material. It is recommended that all house-surgeons should ask patients being prepared for operation whether they have had steroid therapy in the past eighteen months. If so, they should be given 100 to 200 mg. of cortisone acetate intramuscularly 24 hours, and again four hours, pre-operatively. Post-operatively 100 to 200 mg. of cortisone is given daily and gradually reduced over a period of a week—by mouth if the patient can take it, by injection if he cannot. If collapse occurs because these measures have not been carried out, hydrocortisone hemisuccinate should be given intravenously in a dose of 100 to 400 mg. per 24 hours.

D. A. BREWERTON

Paraplegia Following Epidural Anaesthesia. A. DAVIES, B. SOLOMON, and A. LEVENE. *Brit. med. J.*, 1958, **2**, 654.

This is a report of a case in which paraplegia followed epidural anaesthesia. It is believed to be the first one recorded.

Anterior spinal artery syndrome is considered to have occurred; the pathology is discussed.

MAURICE F. HART

Neurological Complications of Epidural Anaesthesia. J. BRAHAM and A. SAIA. *Brit. med. J.*, 1958, **2**, 657.

Two cases are described in which serious neurological complications followed epidural anaesthesia. The pathology was of a local chemical meningo-myelopathy or neuropathy.

MAURICE F. HART

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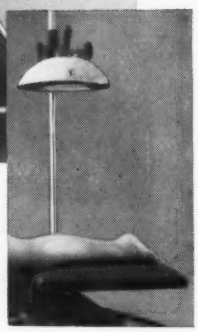

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